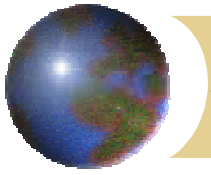


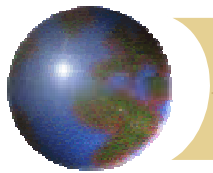
URBAN WOOD/COAL CO-FIRING PROGRAM

University of Pittsburgh
Department of Chemical and
Petroleum Engineering



Goals of Pitt Cofiring Program

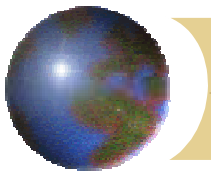
- Cofiring by providing a wood-coal fuel blend that can be used without modification or capital expenditures.
- Clean urban waste.
- Establish specifications for wood/coal blends.
- Facilitate initiation of commercial availability of wood/coal blends.



Pittsburgh Demonstrations

- Pittsburgh Brewing Company (PBC).
- NIOSH - Bruceton Research Center.
- Bellefield Boilers (University of Pittsburgh).

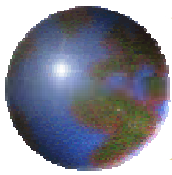




Demonstration I at PBC

- 42,000 lb (steam)/hr chain-grate stoker boiler.
- No plant modifications.
- 18 test burns from four to 72 hours.
- Tub-ground pallet and whole tree (green wood) chips.

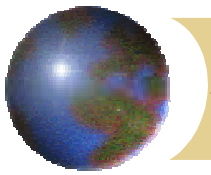




Demonstration I at PBC



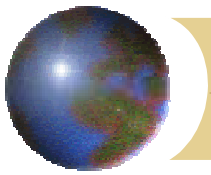
- Up to 10% (by Btu) ground pallets/90% junior pea coal.
- Blend – alternative layers in triaxle truck.
- Some ranking required at delivery grate.
- Acceptable feeding and combustion.



Demonstration at NIOSH



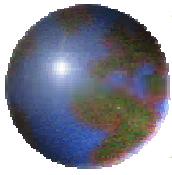
- 55,000 Lb (steam)/hr Keeler boiler.
- Three Detroit RotoGrate spreader feeders.
- No plant modifications.
- 10% (by Btu) ground pallets/90% junior pea coal.



Demonstration at NIOSH



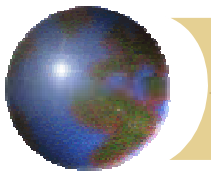
- Blend–alternative layers in triaxle truck, dumped, and reloaded.
- Some raking required at delivery grate and poking at feeders–unacceptable at this plant.
- Acceptable combustion.



Demonstration II at PBC

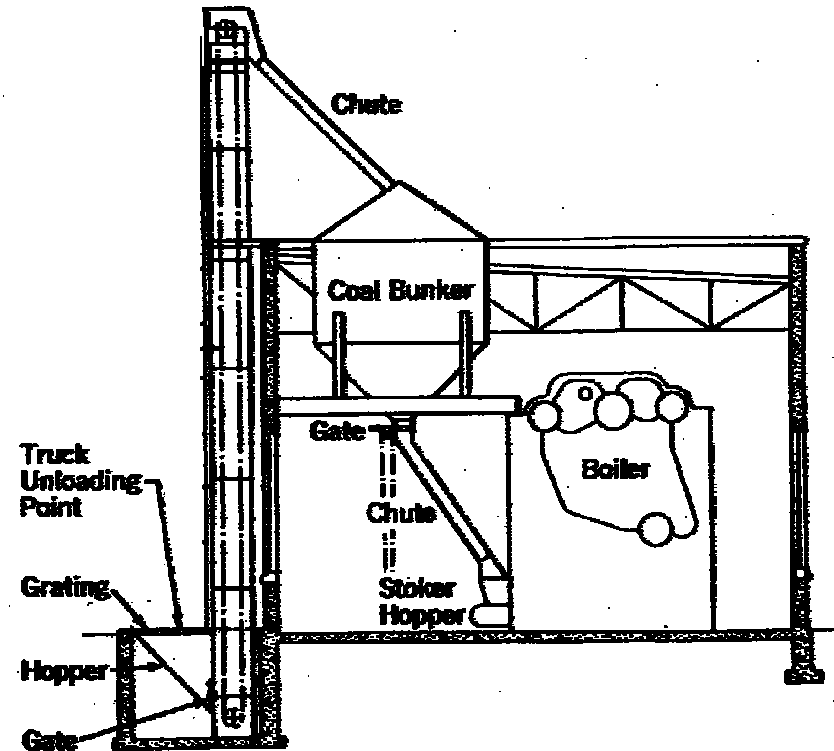
- Two 4-ton mixtures of wood/coal fuel blend.
- Wood prepared by a modified tub grinding method.
- Mixed at the wood processor's site with a with a FECON blender.
- 50% wood by volume (12% by Btu content).

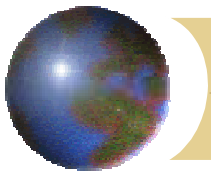




Fuel Conveyance

- Bridging on receiving grating.
- Rat-holing between outside hopper and bucket elevator.
- Fines segregating and bird's nesting in bunker.



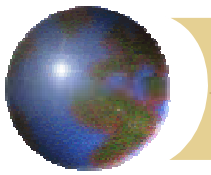


Fuel Conveyance

- Bridging on receiving grating: tub-ground wood content greater than approximately 33%.
- No fuel conveyance problems: whole tree chips (when free of large pieces).



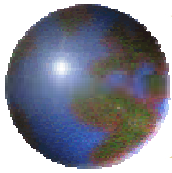
33% mix on NIOSH receiving grating.



Emissions (PBC 72-hour Test)



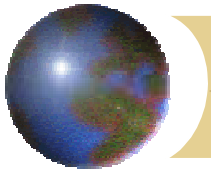
- SO₂ level consistent with low sulfur in pallets.
- NO_x level equivalent or lower than other stokers (Lower NO_x expected with higher volatiles in pallets).
- CO level reasonable, indicating good combustion.
- Opacity unchanged (except when cofiring w/ 40% whole tree chips).



Urban Wood Residues (UWR)

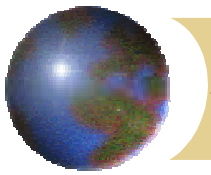
- Urban Tree Residues
 - Tree maintenance.
 - Utility right-of-way.
 - Urban site conversion activities.
- Post-consumer Wood Residue
 - Pallet, wooden container, dunnage and bracing wood residues.
 - Construction and demolition (C/D) wood residues.
 - Urban secondary wood products manufacturing.
 - Municipal solid waste (MSW) wood.





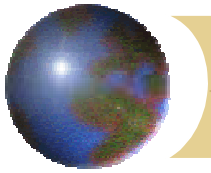
Pallet Wood Residues

- 16% to 18% of all the timber harvested in the US goes into the manufacture of pallets and wooden containers.
- Very low moisture content of 5% to 15%.
- Generally free of paints, stains or other treatments.



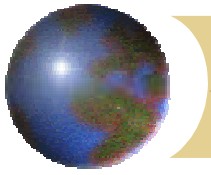
C/D Wood Residues

- Wood is 15% to 85% of debris.
- Can be treated or untreated.
- The may also contain other attached waste.
- The average moisture content is 12% to 15%.
- 57% of construction site disposal cost (w/cardboard).



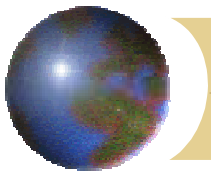
Construction Wood Residue

- 15-25% moisture.
- Frayed-end sticks w/sawdust (if mulched).
- Adhesives in plywood/engineered products.
- Commingled with non-wood wastes.
- <\$22/ton FOB plant.



Demolition Wood Residue

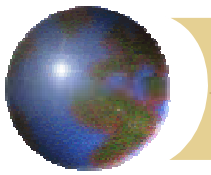
- 5-15% moisture.
- Frayed-end sticks w/sawdust (if mulched).
- Lead-based paint and CCA wood.
- Commingled with non-wood and hazardous wastes.



Wood Processing

- Chippers.
 - Require material w/o hard contaminants.
 - Produces knife cut material, chips.
- Tub grinders, etc.
 - Used when hard contaminants present.
 - Produces mulch.

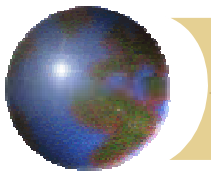




Chips and Mulch

- Chips: Sharp edged, smooth surfaced wafers.
- Mulch: Frayed-end splinters.
- Stoker coal: $\frac{3}{4}$ " x $\frac{1}{4}$ ".

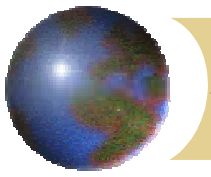




Modified Tub-ground Wood



Modified tub-ground wood used at second brewery demonstration.
Wood has fewer percent fines and larger width to length ratio.

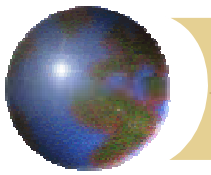


Fuel Blending

- Mixing on ground w/ front-end loader.
- Layering on bed of delivery truck.
- Mixing in blender.



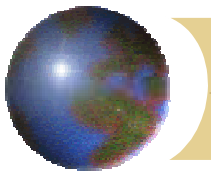
Fuel mixed by layering wood and coal in bed of tri-axel.



Mixing With FECON Blender



Two front-end loaders at the wood processing site preparing the fuel mix by commingling the wood and coal in mixing hopper (PBC Demo II).

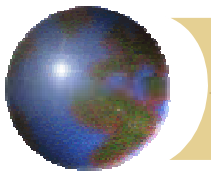


Availability of Selected UWR

Wood Waste	Total Generated (10 ⁶ tons/year)	Available @ at up to \$20/ton (10 ⁶ tons/year)
Construction	16.7	9.7
Demolition	26.4	6.6
Used Pallets ^a	6.5	0.7
Landfilled Pallets ^b	5.1	4.2
Total	54.7	21.2

(a) Includes pallets that are repaired, refurbished, or recycled.

(b) Pallets and dunnage sent to MSW and C/D landfills.



Commercialization



- Wood Processor – Profit, expansion into new markets.



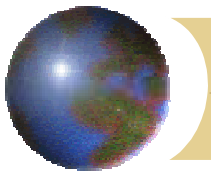
- Coal Vendor – Profit, customer satisfaction.



- Stoker Boiler Operator – Lower fuel price, lower emissions.

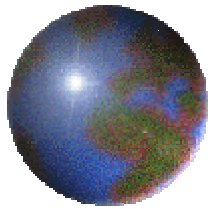


- Environmental Regulators – No deterioration in air emission.



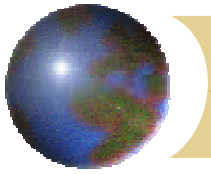
Next Steps

- Continue developing new modified grind method.
- Test new grind method at brewery.
- Demonstrate new blend and new blending method at Bellefield boiler plant (BBP).
- Demonstrate use of construction wood at BBP.
- Demonstrate use of C/D wood at NIOSH.
- Establish commercial blend in Pittsburgh.



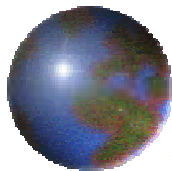
URBAN WOOD/COAL CO- FIRING IN THE BELLEFIELD BOILERPLANT

University of Pittsburgh
Department of Chemical and
Petroleum Engineering



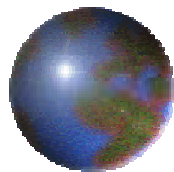
BBP OPERATIONS OVERVIEW

- Eastern Kentucky compliance coal barged to MVTC on Monongahela
- 60-ton railcars to Oakland Campus
- Bucket conveyer/elevator to segregated bunkers

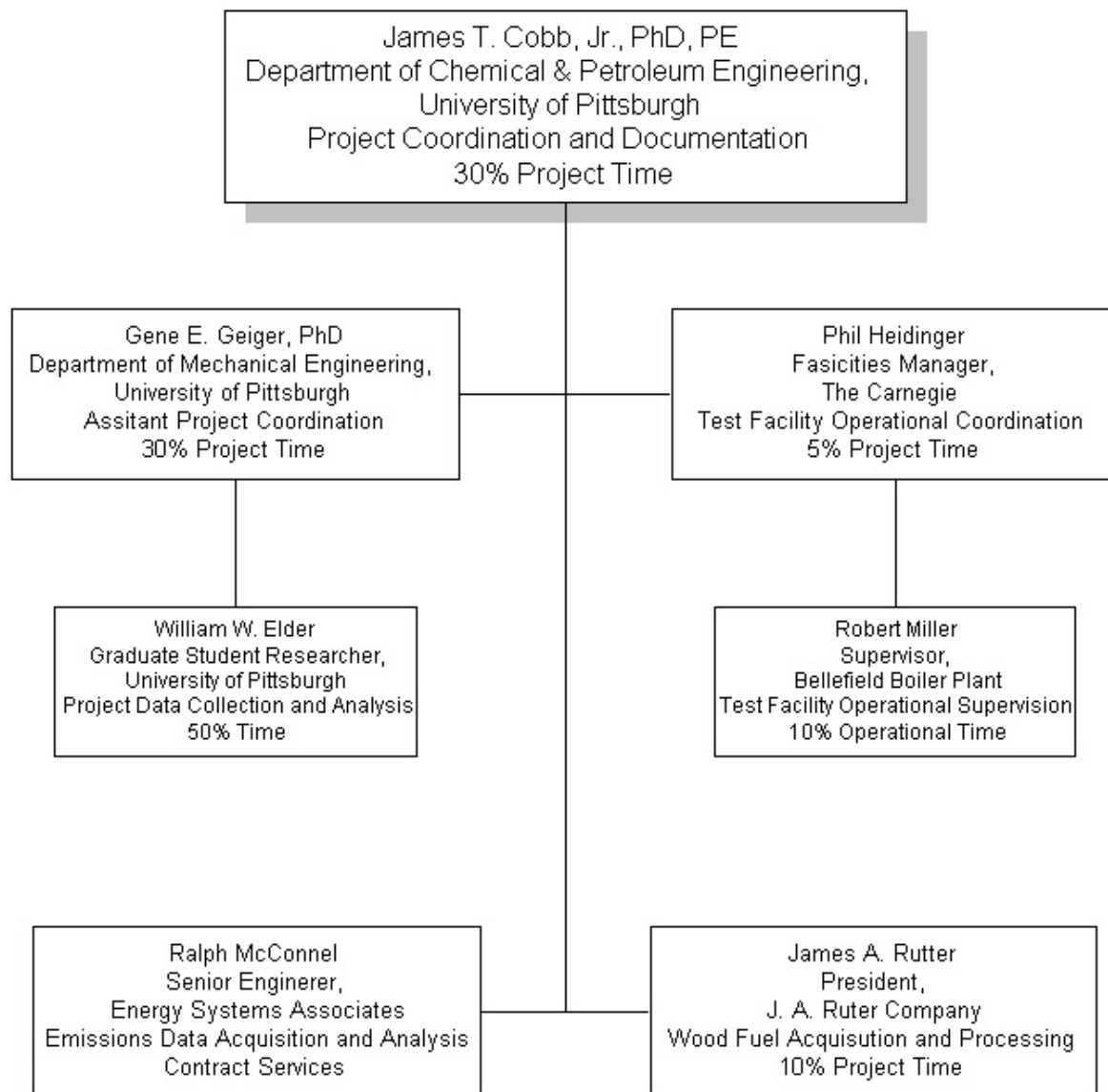


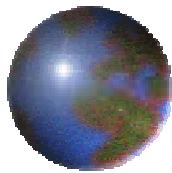
BBP BOILER PLANT

	<u>Boiler #1</u>	<u>Boiler #2</u>	<u>Boiler #3</u>	<u>Boiler #4</u>	<u>Boiler #5</u>
<u>Manufacturer</u>	Babcock & Wilcox	Springfield Boiler	Zurn Industries	Springfield Boiler	Erie City Iron Works
<u>Boiler Installed</u>	1957	1946	1977	1946	1965
<u>Boiler Type</u>	Stirling Boiler, Water Tube. Two Drum	Cross Drum, Water Tube, Sectional Header	Two Drum, Water Tube	Cross Drum, Water Tube, Sectional Header	Two Drum, Water Tube
<u>Stoker Type</u>	B&W Chain Grate Stoker	Westinghouse Nine Retort Underfeed Stoker	Laclede Chain Grate Stoker	Westinghouse Nine Retort Underfeed Stoker	Laclede Chain Grate Stoker
<u>Coal Capacity</u>	100,000 lb/hr	85,000 lb/hr	100,000 lb/hr	75,000 lb/hr	100,000 lb/hr
<u>Gas Capacity</u>	57,000 lb/hr	None	100,000 lb/hr	None	57,000 lb/hr
<u>Oil Capacity</u>	None	None	100,000 lb/hr	None	None
<u>Air Pollution Control System</u>	None	None	Multicyclones for Dust Collection	None	Multicyclones for Dust Collection
<u>Heat Recovery</u>	None	None	Economizer	None	None
<u>Coal Consumption</u>	15,350 ton/yr	3,180 ton/yr	12,910 ton/yr	2,110 ton/yr	13,760 ton/yr

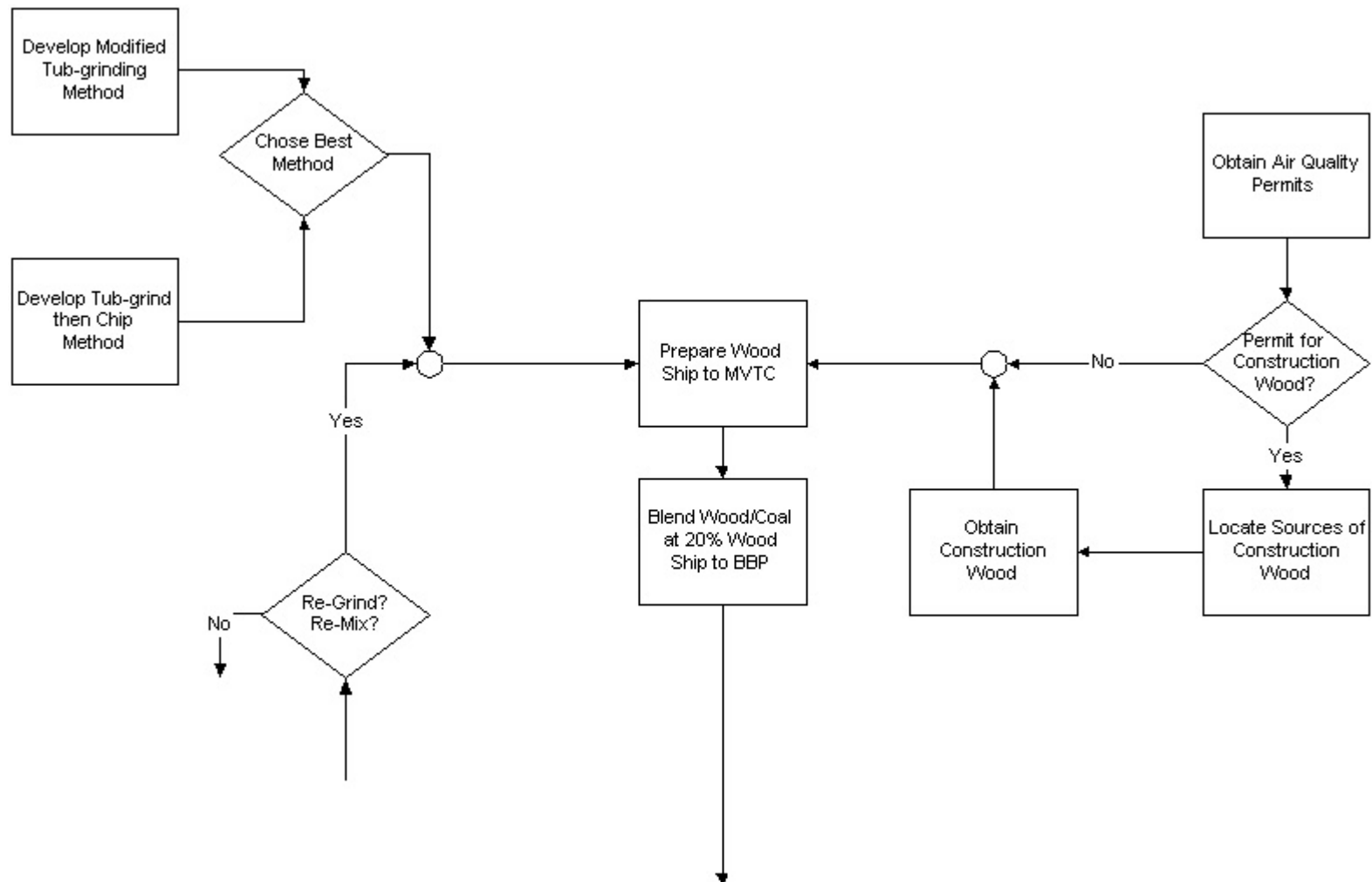


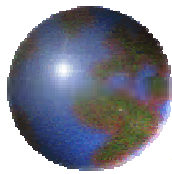
PROJECT ORGANIZATIONAL CHART



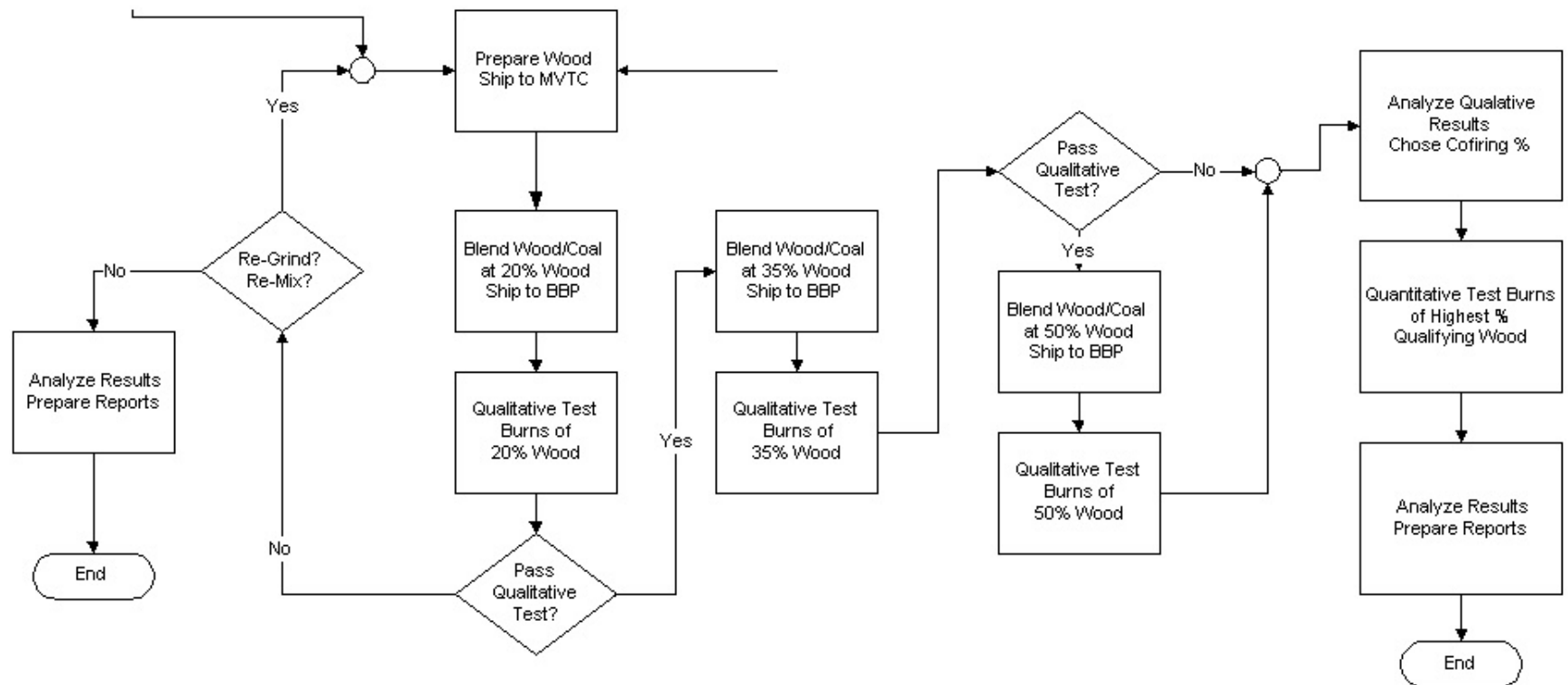


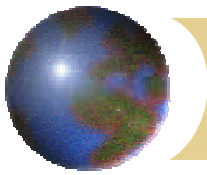
BBP LOGIC DIAGRAM Part A





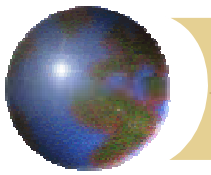
BBP LOGIC DIAGRAM Part B





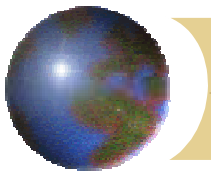
BBP Milestone Plan

A. Identification Number	B. Planning Category (Work Breakdown Structure Tasks)	C. Program/Project Duration														D. Comments (Notes, Name of Performer)
		M	J	J	A	S	O	N	D	J	F	M	A	M		
Task 1.1	AQP for Pallet Wood Cofiring					Δ									University	
Task 1.2	AQP for Construction Wood Cofiring					Δ									University	
Task 2.1	Develop Modified Tub-Grind Method					Δ									J. A. Rutter	
Task 2.2	Develop Modified Hammermill Method							Δ							Emery	
Task 3	Collect Construction Wood					▽		▽		▽	Δ				Rutter/Emery	
Task 4	Process Wood						▽	▽			Δ				Rutter/Emery	
Task 5	Blend and Transfer Fuel to Bellefield						▽	▽	▽			Δ			MonValley	
Task 6.1	Qualitative Test Burn @ 20%						Δ								Bellefield	
Task 6.2	Qualitative Test Burn @ 35%								Δ						Bellefield	
Task 6.3	Qualitative Test Burn @ 50%									Δ					Bellefield	
Task 7	Stack Testing											Δ			ESA	
Task 8	Collect Data					▽	▽	▽	▽			Δ			University	
Task 9	Coordinate, Report		▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	▽	Δ	University	



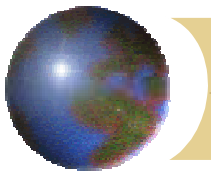
BBP Planned Test Burn Schedule

Phase	Test Burn	Fuel Blend	Wood Fuel Weight	Coal Fuel Weight	Total Fuel Weight
1	1-A	20% wood by volume	56 tons	7 tons	63 tons
1	1-B	35% wood by volume	45.5 tons	12.3 tons	57.8 tons
1	1-C	50% wood by volume	35 tons	17.5 tons	52.5 tons
2	2-A	0% wood by volume	0 tons	60 tons	60 tons
2	2-B	50% wood by volume	35 tons	17.5 tons	52.5 tons



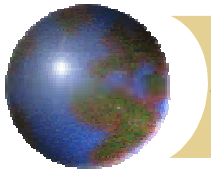
BBP Test Plan – All Phases Part 1

I	The Allegheny County Health Department (ACHD) will be notified of the date and expected time of the test burn.
II	The test boiler will be lit off and operating with coal prior to the test burn.
III	The test will begin with a nearly empty bunker. The railcar containing the fuel blend will be unloaded and conveyed up to the bunker. One or more railcars of coal will be loaded on top of the fuel blend in the bunker.
IV	The flow of the test fuel into the bunker and from the bunker into the boiler will be visually inspected for bridging.
V	A test burn will begin when the test fuel first enters the boiler's firebox as determined by visual inspection. This time will be recorded and reported to ACHD.
VI	BBP staff will operate the boilerplant using standard operational procedures with advise from ESA on adjustments to the combustion controls of the boiler that will optimize the combustion of the wood-coal fuel blend.



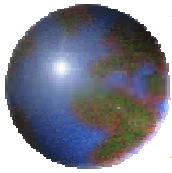
BBP Test Plan – All Phases Part 2

VII	The fuel blend will be periodically inspected and samples taken by University personnel as it enters the boiler. The material will be graded for wood/coal particle segregation and its bulk density will be determined.
VIII	The combustion behavior of the fuel blend will be periodically determined by visual inspection of the fuel bed.
IX	The ash on the grate will be periodically inspected and samples taken by University personnel. The material will be graded for rate of burnout and morphological changes.
X	University personnel will record control room data and make copies of the chart recordings and computer printouts.
XI	A test burn will end when the last of the test fuel has passed through the boiler's firebox as determined by visual inspection plus the fuel bed retention time. This time will be recorded and reported to ACHD.
XII	If any operational difficulties occur during the test burn, the test burn will be discontinued and the difficulties reported to ACHD.



BBP Test Plan –Phase 2

I	Test instruments will be temporarily installed in the boiler to monitor combustion gases and particulates.
II	The continuous flue gas sampling of O ₂ , CO, NO _x , and SO ₂ will be made.
III	Periodic sampling of particulate matter will be made.
IV	Control room data will be recorded by ESA.



Materials and Combustion Testing

- **Materials Testing**

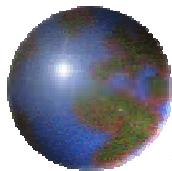
The following samples will be collected by Pitt and sent to a materials testing laboratory for the listed tests.

- Wood: Proximate, Ultimate, Ash Elemental
- Coal: Proximate, Ultimate, and Ash Elemental
- Bottom Ash: Ash Elemental, LOI

- **Combustion Testing**

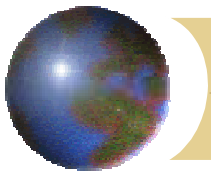
The following samples will be taken by ESA.

- Gases: Continuous sampling: O₂, CO, NO_x, and SO₂
- Particulates: Periodic sampling



Data Recorded

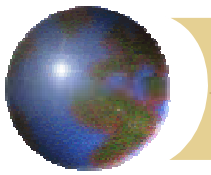
Operation	Parameter	Measurement Methods
Test Burn	Start Time	Visual inspection and clock
	Ending Time	Visual inspection, clock and estimated retention time
Fuel Blending	Volume Wood	Front-end loader bucket number
	Weight Wood	JAR and/or ETS scales
	Volume Coal	Front-end loader bucket number
	Weight Coal	BBP scales
	Difficulties	Qualitative description
Flow into Bunker	Segregation	Visual inspection and description
	Bridging	Visual inspection and description
Flow out of Bunker	Segregation	Visual inspection and description
	Bridging	Visual inspection and description
Fuel Burning Characteristics	Flame Behavior	Visual inspection and description
	Fuel Burnout	Visual inspection and estimation of percent unburned wood content
	Segregation on the Bed	Visual inspection and description of ash morphology
Fuel Consumption Rate	Coal Scales	Number of dumps
Steam Make	Temperature, Pressure, Flow rate	Copies of chart recording



PHASE I Task 1.0

Obtain Air Quality Permit (AQP) Variances for Cofiring Wood

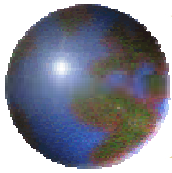
- Task 1.1 AQP Variance for Cofiring Pallet Wood
Petition Allegheny Health Department for variance: Provide ACHD with a detailed project plan; and the results of previous cofiring demonstrations.
- Task 1.2 Obtain AQP Variance for Cofiring Construction Wood
Petition Allegheny Health Department for variance: Provide ACHD with a detailed project plan; the results of previous cofiring demonstrations; a list of participating construction contractors; and the quality assurance plan.



PHASE I Task 2.0

Develop Processed Urban Wood Chip

- Task 2.1 Develop Wood Chip by Modified Tub Grinding Method
Optimize cut- off plate and sizing screen configuration.
- Task 2.2 Develop Wood Chip by Tub Grinding the Chip Method
Develop procedures for transferring tub ground material through wood chipper.



PHASE I Task 3.0, 4.0 and 5.0

- Task 3.0 Obtain Construction Wood

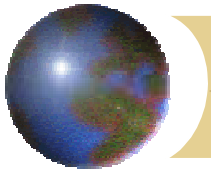
Contact Builder's Associations; write quality assurance plans: place roll- offs at construction sites.

- Task 4.0 Process Wood,

Process wood by the best method of Task 2.

- Task 5.0 Blend Wood

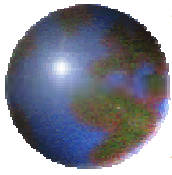
Mix wood and coal on ground or in FECON blender.



PHASE I Task 6.0

Determine Optimum Wood- Coal Fuel Blend

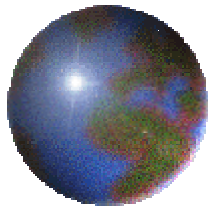
- Task 6.1 Determine Characteristics of 20% Fuel Blend
Deliver wood/coal fuel blend to BBP; observe flow through conveyances; and observe combustion characteristics,
- Task 6.2 Determine Characteristics of 35% Fuel Blend
Deliver wood/coal fuel blend to BBP; observe flow through conveyances; and observe combustion characteristics.
- Task 6.3 Determine Characteristics of 50% Fuel Blend
Deliver wood/coal fuel blend to BBP; and observe flow through conveyances; observe combustion characteristics.



PHASE I Task 7.0

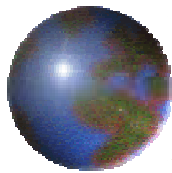
- Task 7.0 Determine Cofiring's Effect on Emissions

Stack testing of optimized fuel blend.

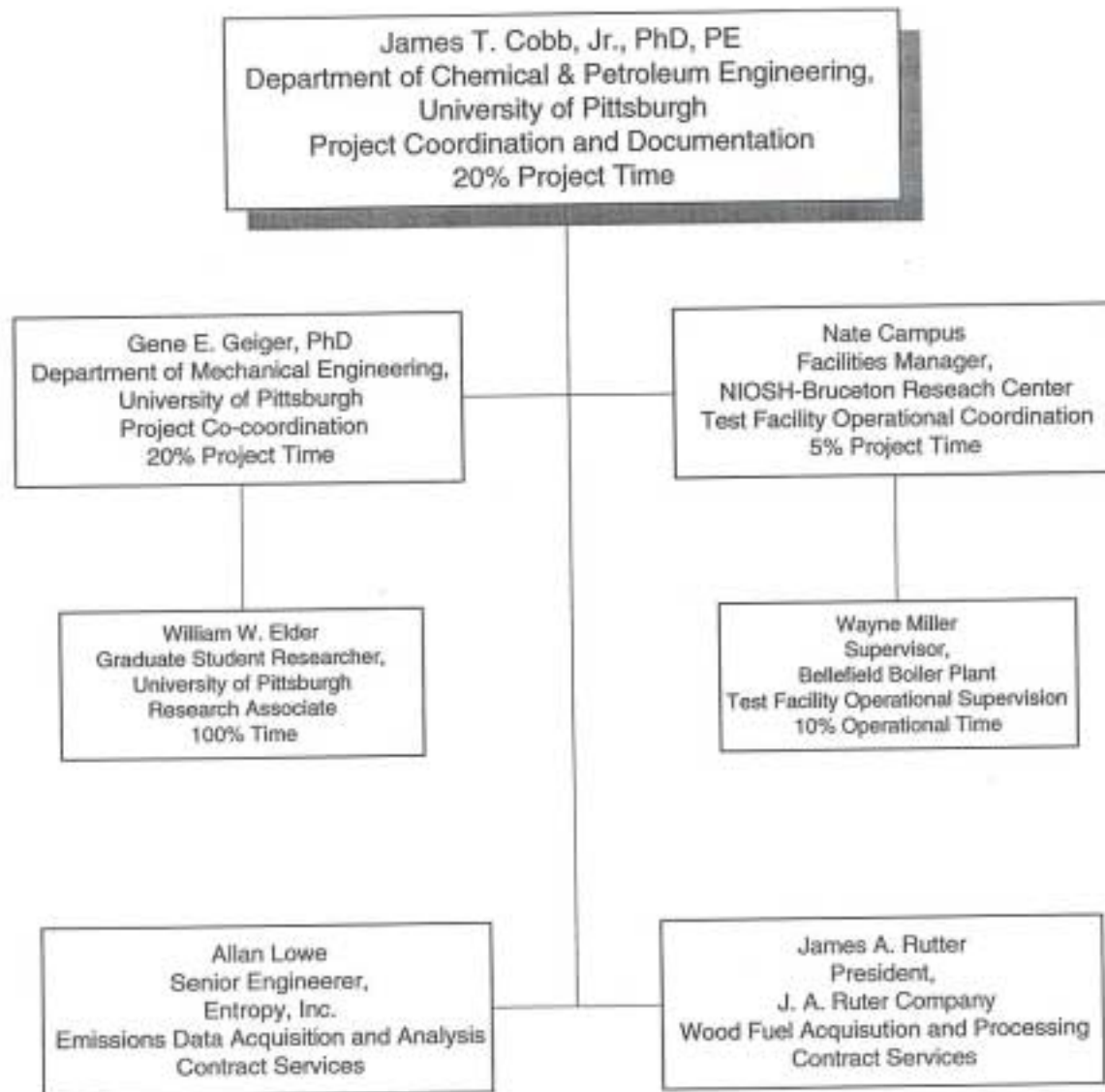


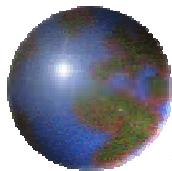
URBAN WOOD/COAL CO- FIRING IN THE NIOSH BOILERPLANT

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Department of Chemical and
Petroleum Engineering

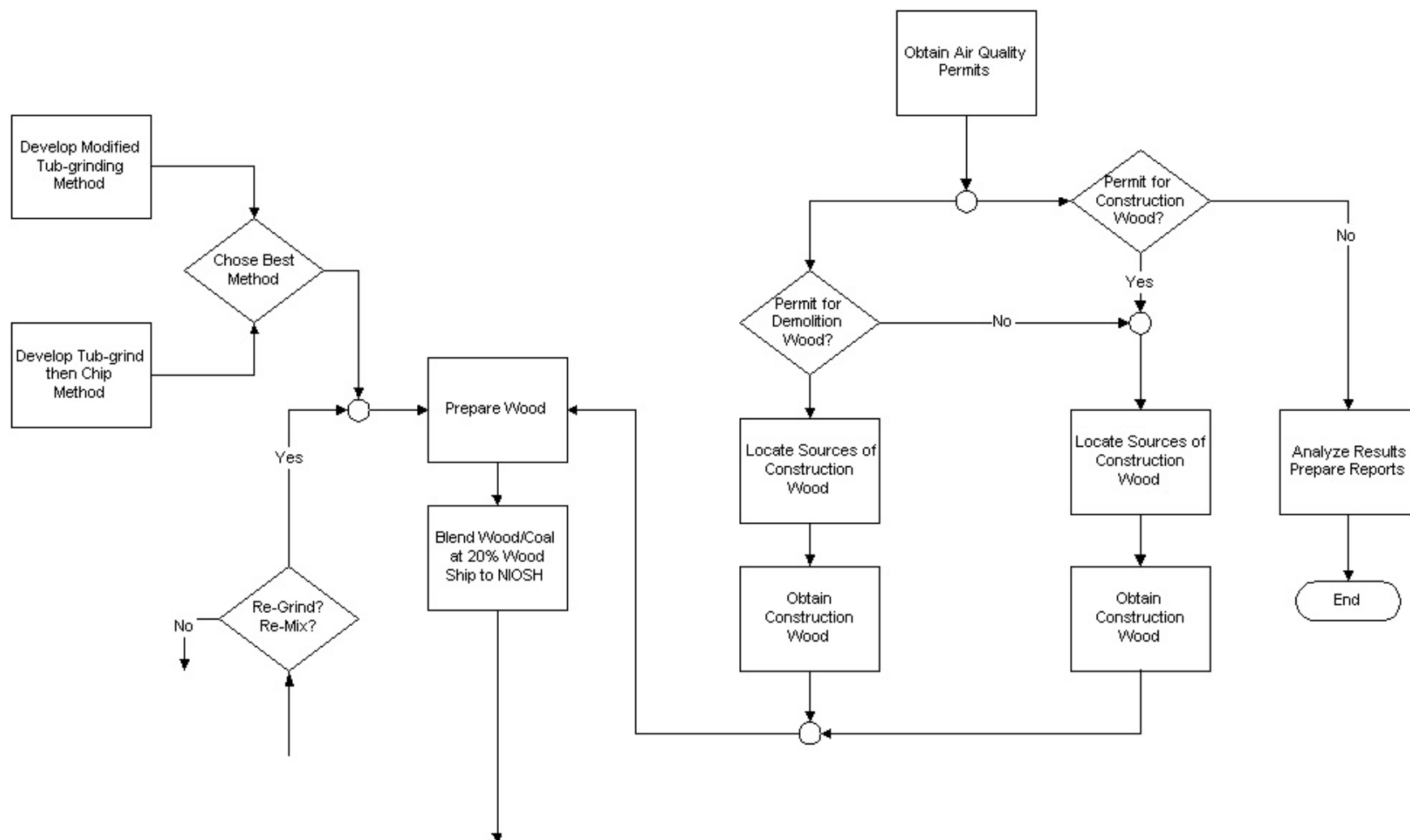


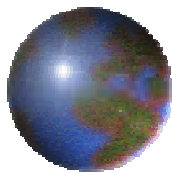
PROJECT ORGANIZATIONAL CHART PHASE I



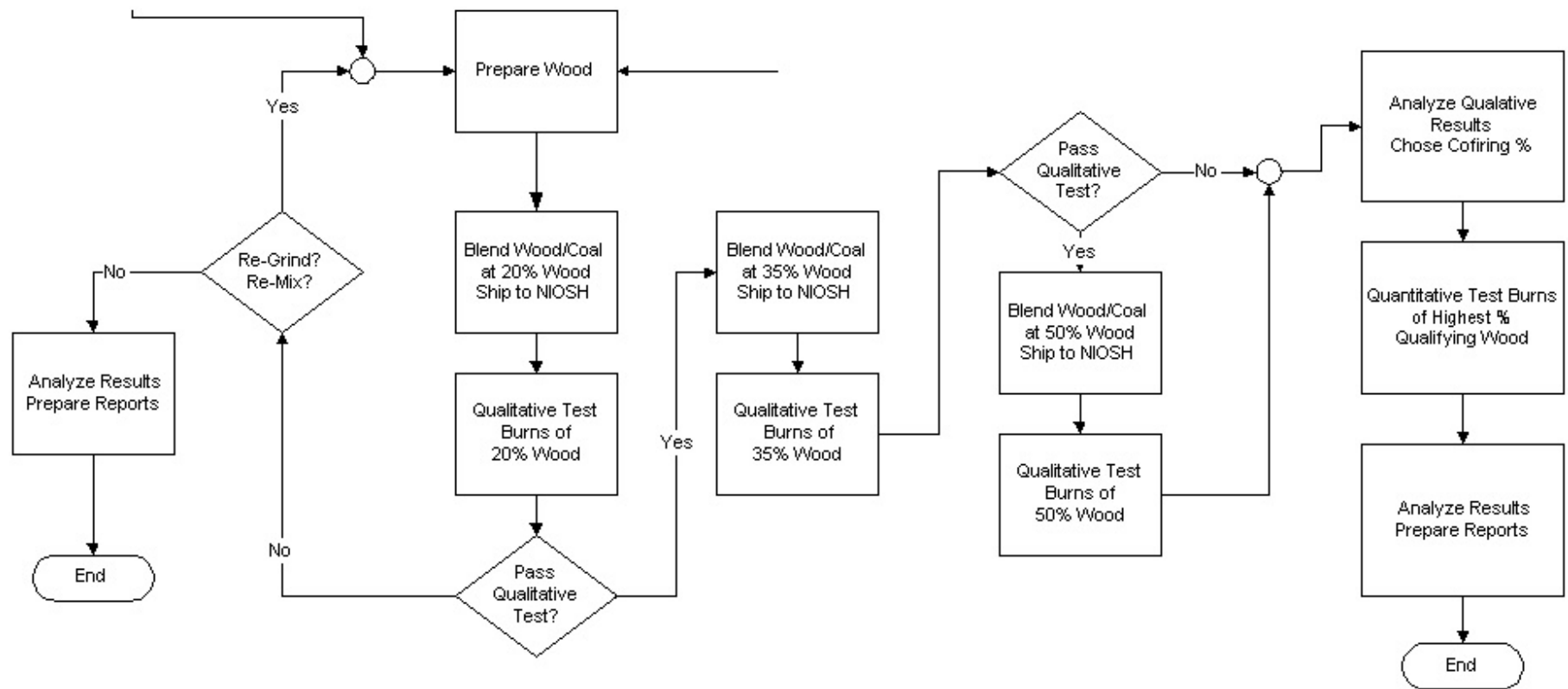


NIOSH LOGIC DIAGRAM Part A





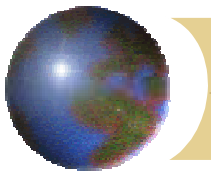
NIOSH LOGIC DIAGRAM Part B





NIOSH Milestone Plan

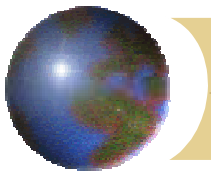
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PHASE I Task 1.0

Obtain Air Quality Permit (AQP) Variances for Cofiring Wood

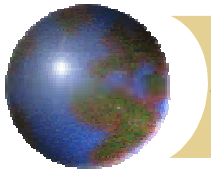
- Task 1.1 AQP Variance for Cofiring Construction Wood
Petition Allegheny Health Department for variance: Provide ACHD with a detailed project plan; and the results of previous cofiring demonstrations; a list of participating construction contractor, and the quality assurance plan.
- Task 1.2 Obtain AQP Variance for Cofiring Demolition Wood
Petition Allegheny Health Department for variance: Provide ACHD with a detailed project plan; the results of previous cofiring demonstrations; a list of participating demolition contractor; and the quality assurance plan.



PHASE I Task 2.0

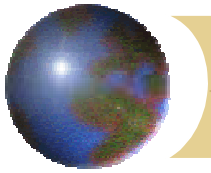
Develop Processed Urban Wood Chip

- Task 2.1 Develop Wood Chip by Modified Tub Grinding Method
Optimize cut- off plate and sizing screen configuration.
- Task 2.2 Develop Wood Chip by Tub Grinding the Chip Method
Develop procedures for transferring tub ground material through wood chipper.



PHASE I Task 3.0, 4.0 and 5.0

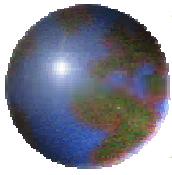
- Task 3.0 Obtain Construction and Demolition Wood
Contact Builder's Associations work with PA DEP;
write quality assurance plans: place roll- offs at
construction sites.
- Task 4.0 Process Wood,
Process wood by the best method of Task 2.
- Task 5.0 Blend Wood
Mix wood and coal in FECON blender.



PHASE I Task 6.0

Determine Optimum Wood- Coal Fuel Blend

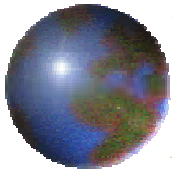
- Task 6.1 Determine Characteristics of 20% Fuel Blend
Deliver wood/coal fuel blend to BRC; observe flow through conveyances; and observe combustion characteristics,
- Task 6.2 Determine Characteristics of 35% Fuel Blend
Deliver wood/coal fuel blend to BRC; observe flow through conveyances; and observe combustion characteristics.
- Task 6.3 Determine Characteristics of 50% Fuel Blend
Deliver wood/coal fuel blend to BRC; and observe flow through conveyances; observe combustion characteristics.



PHASE I Task 7.0

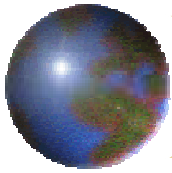
- Task 7.0 Determine Cofiring's Effect on Emissions

Stack testing of optimized fuel blend.



PHASE II Task 1.0 and 2.0

- Task 1.0 Develop Wood/Coal Fuel Specifications for BRC Boilerplant
Consult with BRC on wood/coal fuel specifications.
- Task 2.0 Develop Coal Vendor/ Wood Processor Relationships
Contact coal vendor and wood processor;
inform them of subsidy for cofiring fuel



PHASE II Task 3.0 and 4.0

- Task 3.0 Monitor Wood/Fuel Contract
Monitor activities at BRC boilerplant related to fuel use.
- Task 4.0 Promote Wood/Coal Cofiring
Contact local stoker boiler operators, state and federal engineering advisory/consultant groups, other interested parties: provide information.